Optics development for the Con-X/SXT telescope at OAB (Italy): a status report

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- review of the activities related to the SXT optics development on course at OAB;
- results obtained with *Alumina* carriers;
- results obtained with SiC carriers;
- future plans.

Con-X Mission Facility Science Team Meeting
Harvard-Smithsonian CfA - May 3/4, 2001

Project short overview:

OAB is currently investigating the SXT optics realization option based on the use of carriers made of ceramic materials for making integral mirror shells with Wolter-I profile. *Compared to Ni, ceramic materials present the great advantage of a much lower density (a factor > 2.6)*

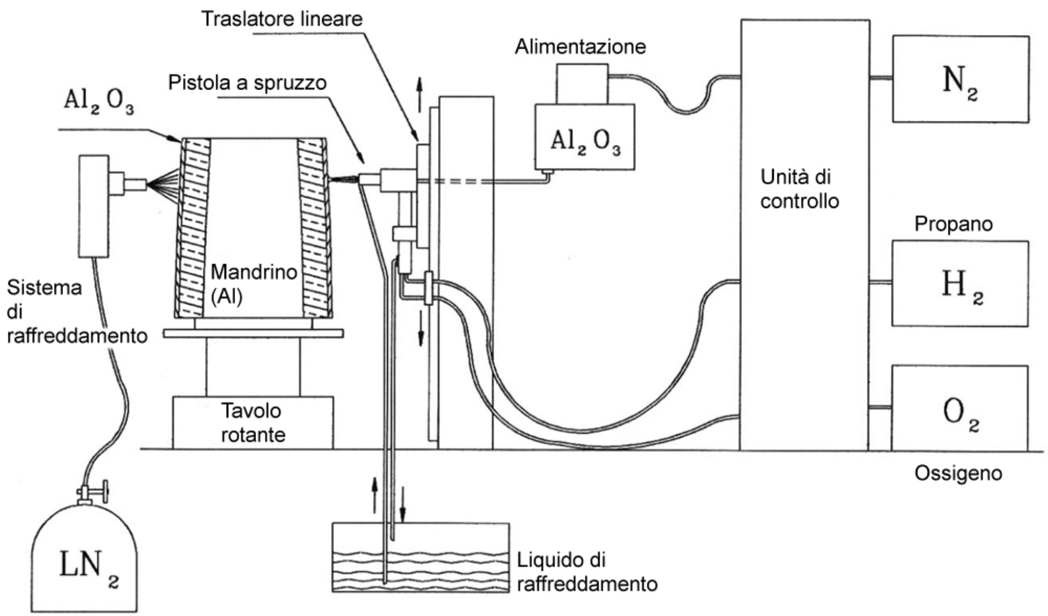
- Mirror shells production method: epoxy replication
- Materials under investigation for making the carriers:
  - ✡ CVD *Silicon Carbide* (SiC):
    (cost at present large but high thermal-mechanical characteristics);
  - ✡ plasma-sprayed *Alumina* (Al_2O_3)
    (*low cost but poorer mechanical parameters).*

The Con-X-SXT past and present activities are carried out exploiting the mandrel with polynomial profile fabricated to prove the feasibility of the WFXT mission. Ø = ***60 cm*** Total Height: ***24 cm*** *(to fit the WFXT wide field application)*

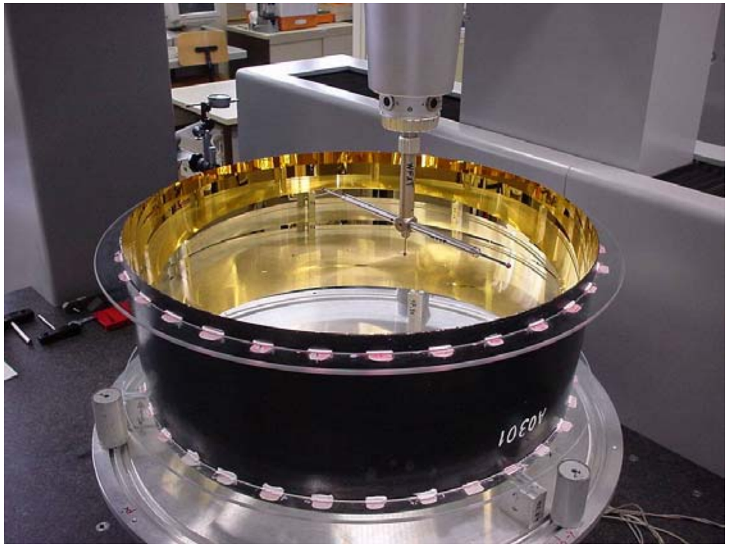
N.B.: the low mirror height tends to enhance the out-of-phase roundness errors of the shell in determining the optics imaging quality

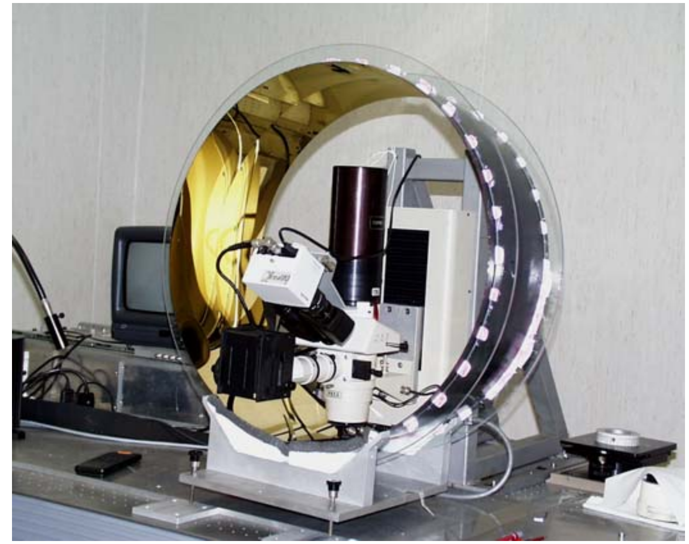
N.B.#2: the profile of the WFXT manufactured mandrel with polynomial shape introduces an intrinsic error for on-axis photons of 8 arcsec HEW.

Realization of *Alumina* carriers by Plasma Spray: a low cost process working at room temperature



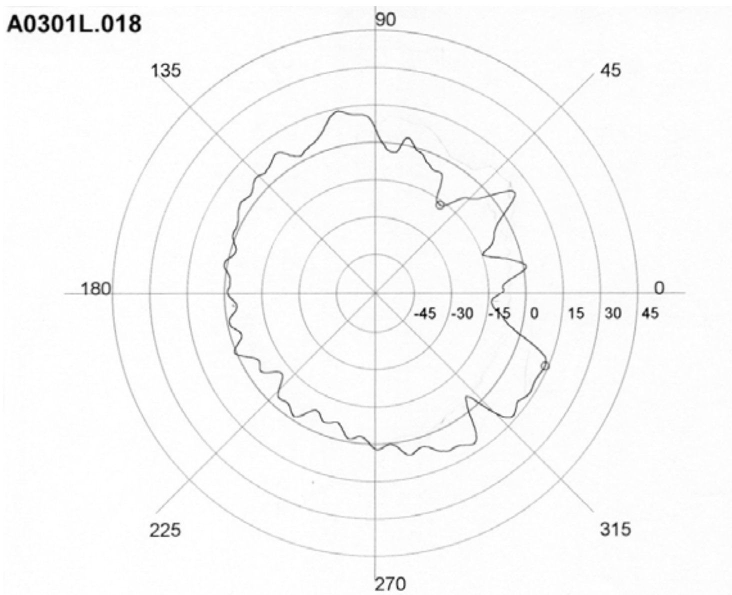
Thin wall Al_2O_3 mirror shell



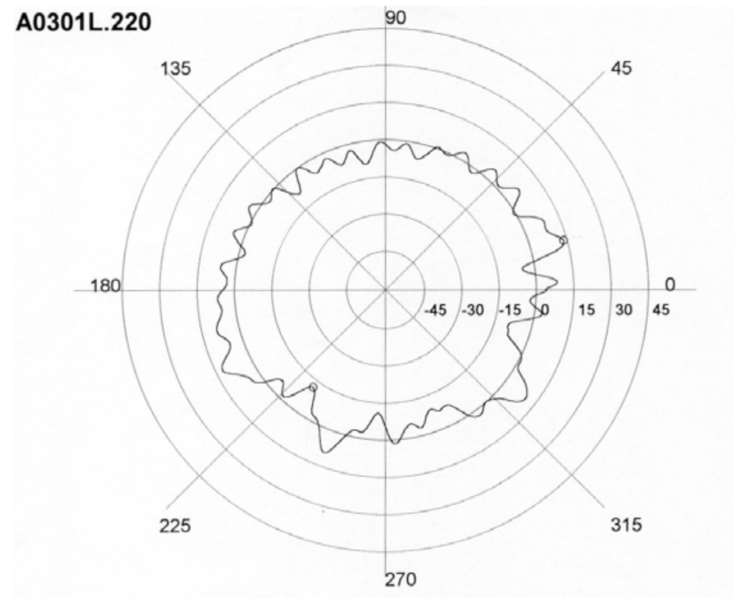


- Diameter: 600 *mm*
- Thickness: 1 *mm*
- The thickness to diameter ratio is near to the weight requirements of Con-X/SXT

Thin wall Al_2O_3 shell circularities



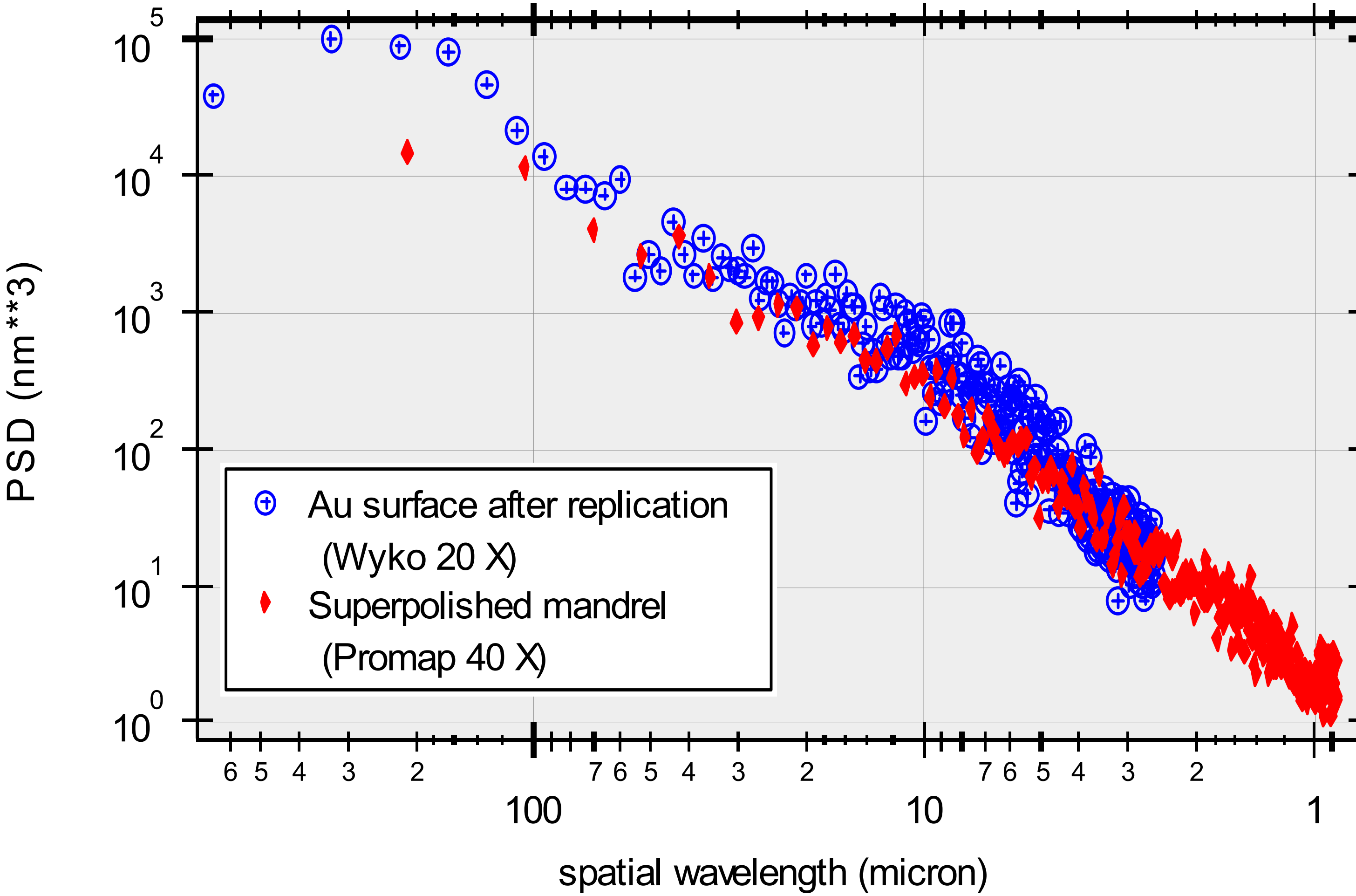
Hyperbole side



Parabola side

- The shell has been replicated using stiffening glass rings with 32 glued points
- The mean P-V of the waves is about 5-6 microns
- The waviness of the profile match the positions of the glued points
- The next replication will be done using a continuous line of glue

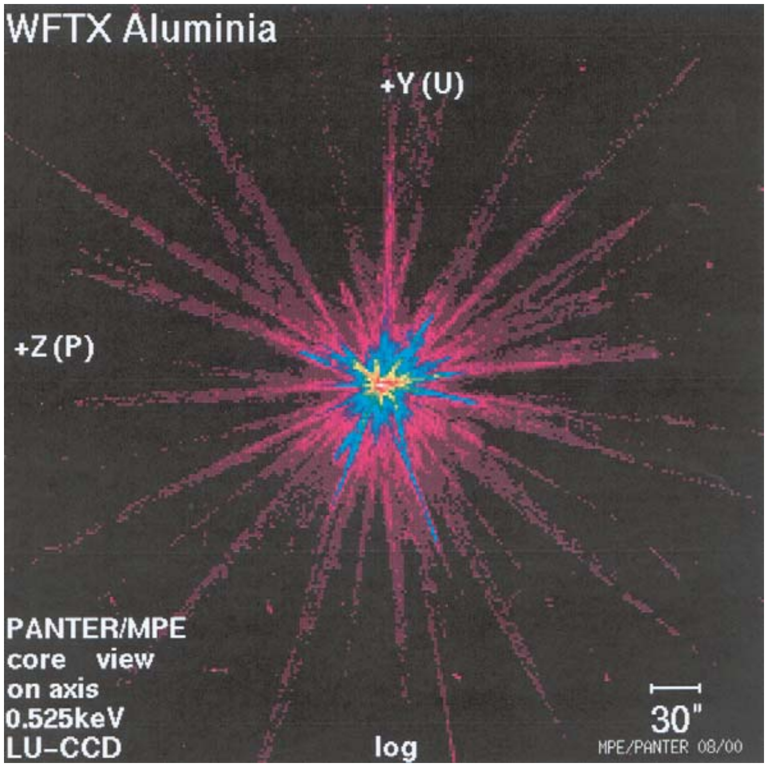
Microroughness: Au mirror shell vs superpolished mandrel



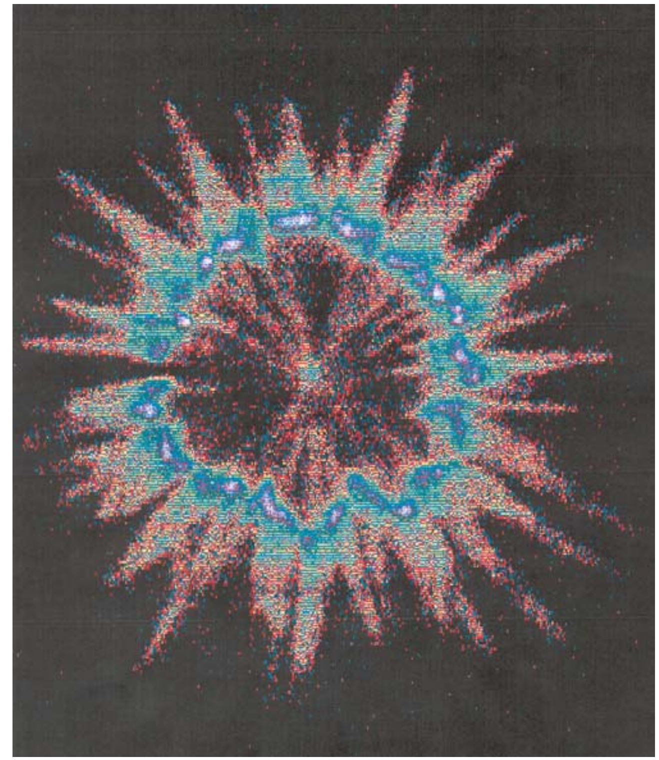
Spatial Wavelength Window: 3 µm - 200 µm:

σ–mandrel = 2.8 Å σ–mirror = 4.6 Å

X-Ray imaging tests performed at the Panter MPE facility

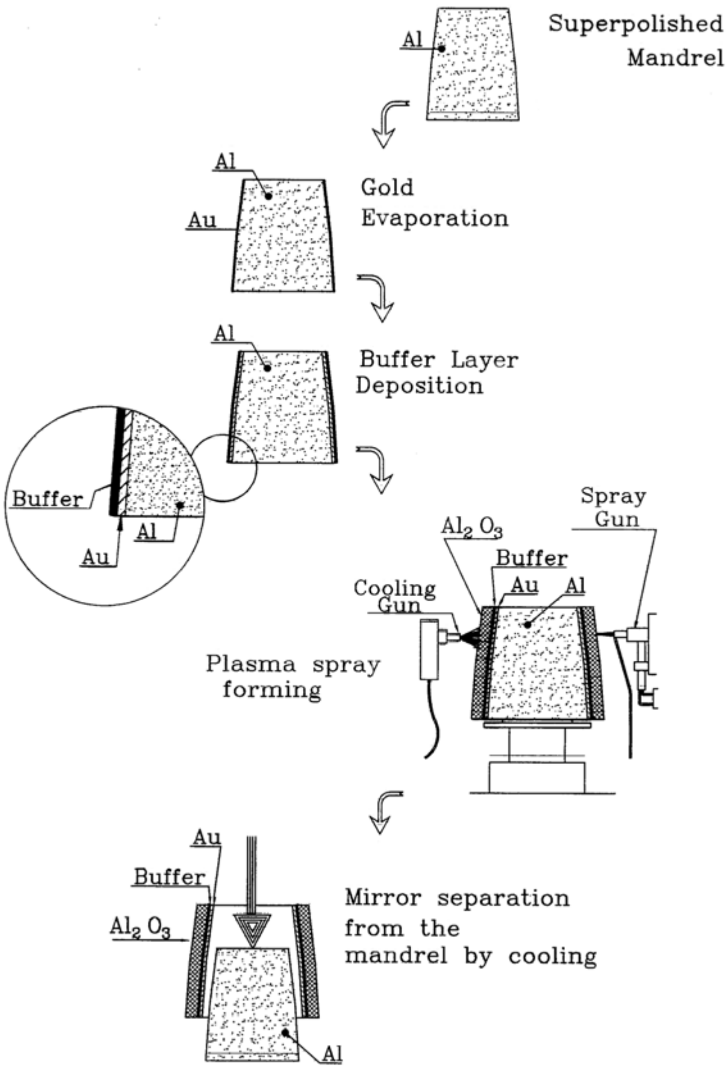


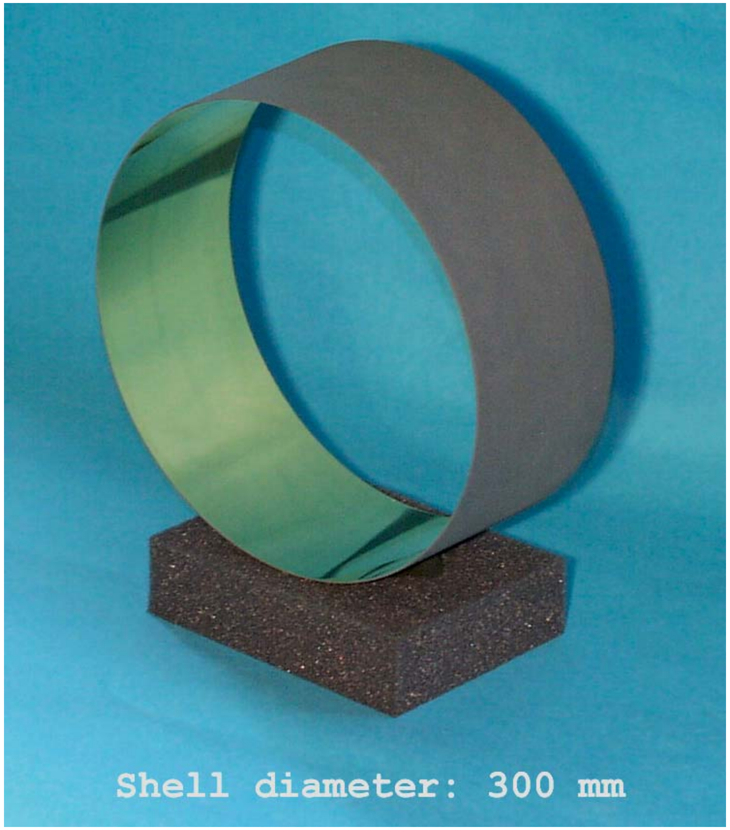
In-focus image at 0.525 KeV (HEW=45 arcsec)



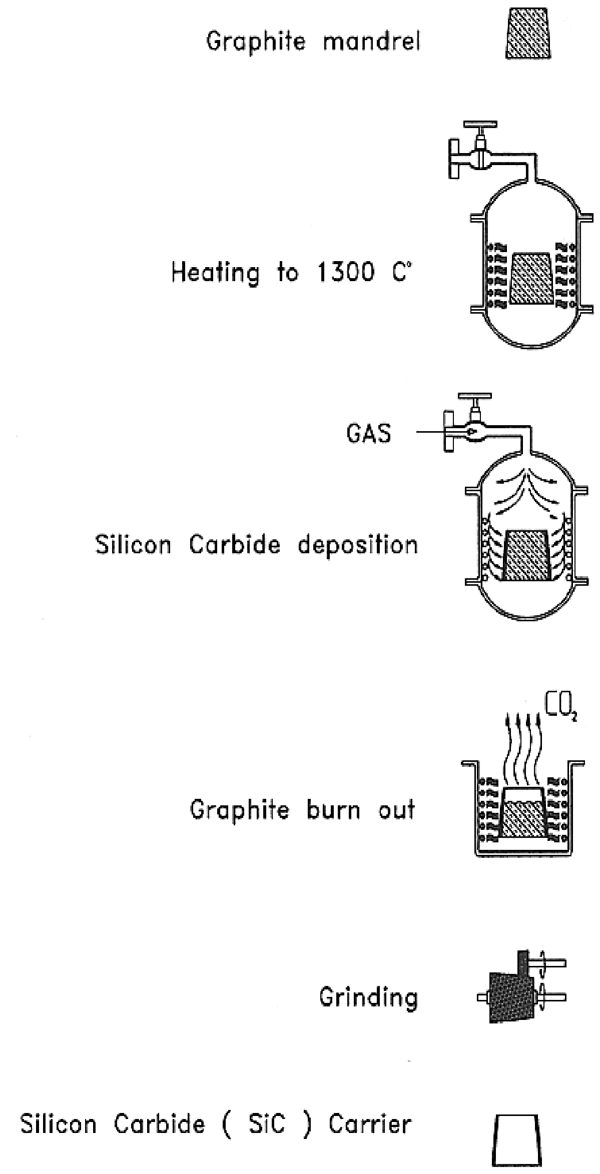
50 mm intrafocus ring at 1.5 KeV

Al2O3 direct deposition process





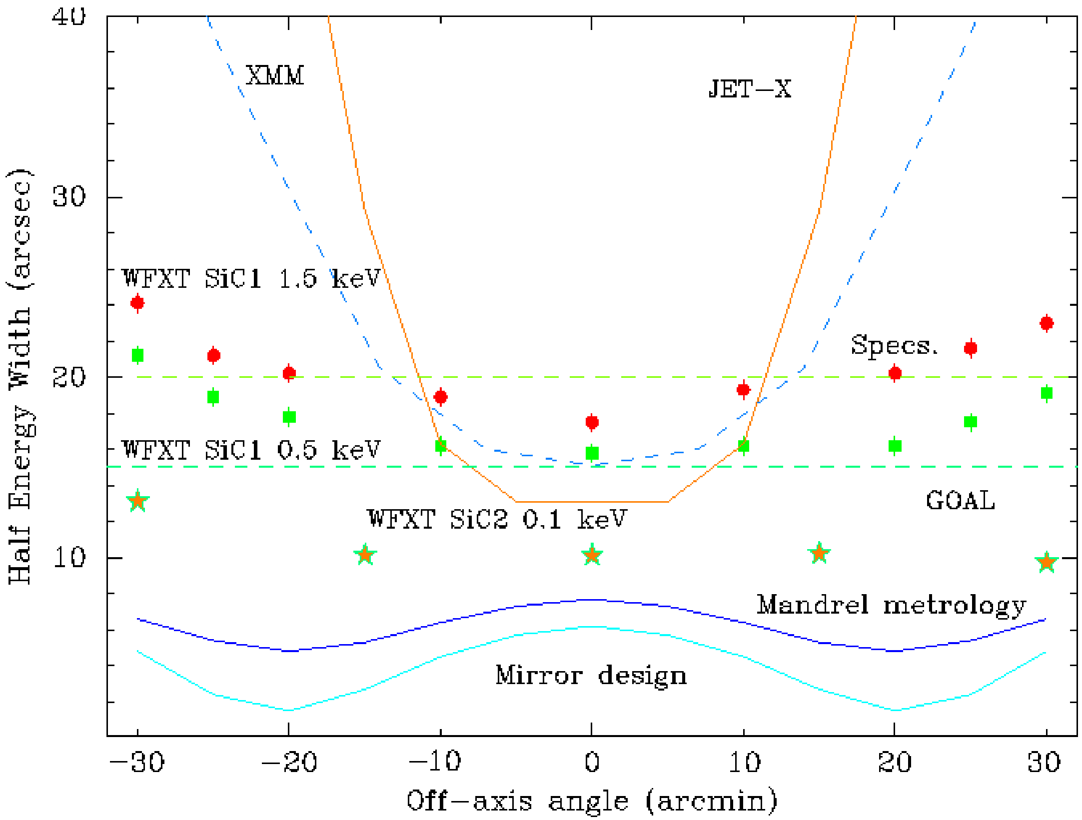
Realization of *SiC* carriers by CVD: <u>a process working at high temperature</u> (at present quite expensive)



SiC shells produced for thefeasibility study of the WFXT mission concept

- Sic-1: 3 mm thick   Weight: 5.4 Kg
- Sic-2: 2 mm thick   Weight: 3 Kg

(Diameter 600 mm - length 240 mm)

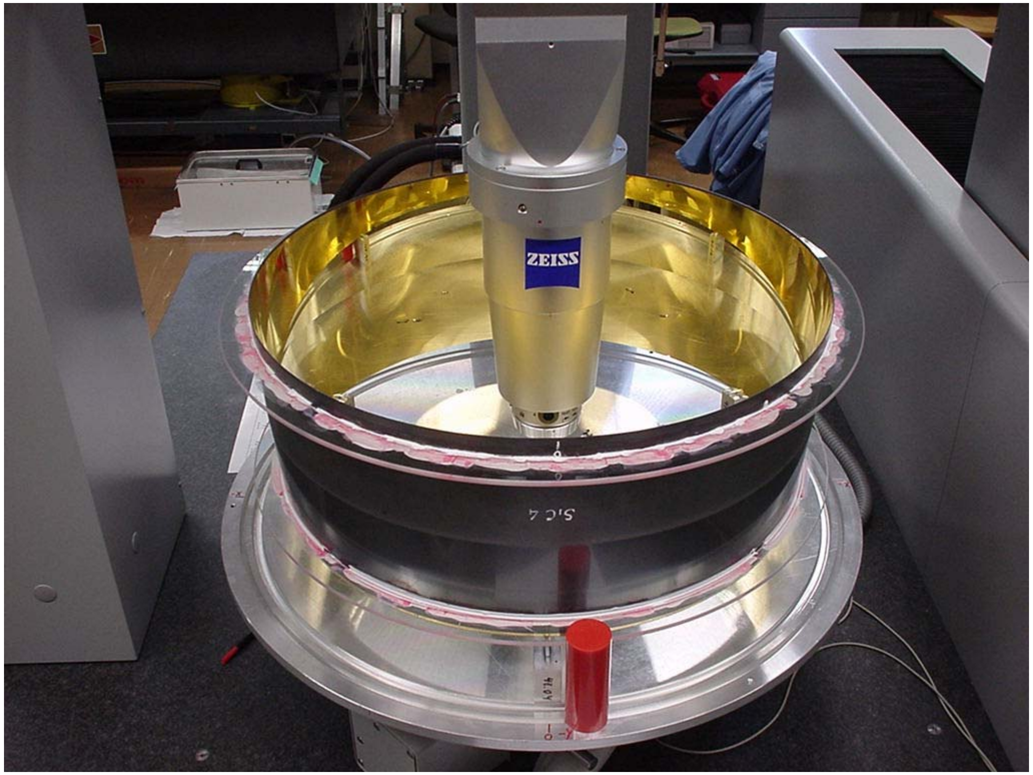


The Sic-2 shell has reached an HEW of 10 arcsec in very good agreement with the SXT requirements

In October 2000 a third shell with a thickness of 1 *mm* and a weight of 1.4 Kg has been successfully replicated.

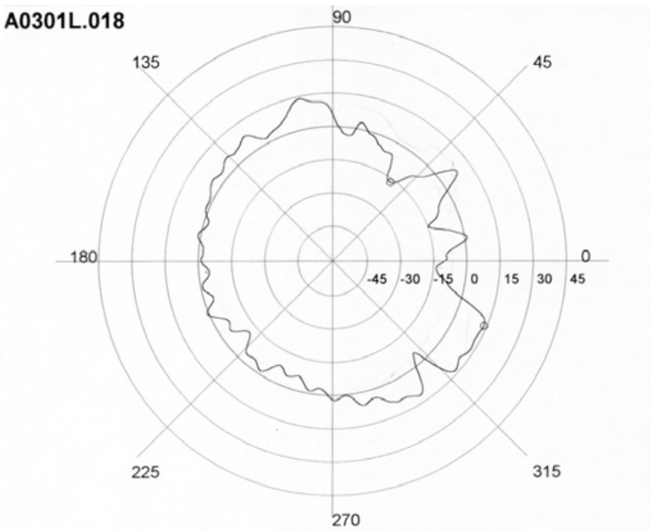
The matured experience with these mirror shells can be exploited also for the Constellation-X SXT development.

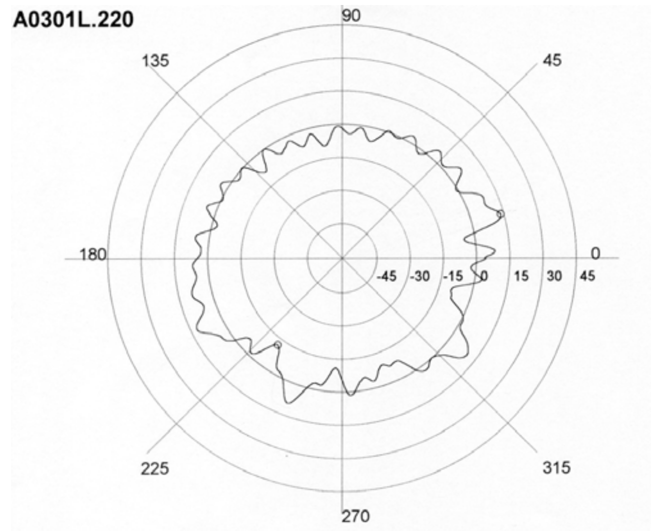
Thin wall SiC mirror shell (SiC # 4)



- Diameter: 600 *mm;*
- Thickness: 1 *mm;*
- Weight: 1.4 *Kg;*
- *Thickness-to-diameter* ratio very close to the Con-X/SXT mass requirements.

Thin wall (1.0 *mm*) Al_2O_3 vs. SiC shell circularities

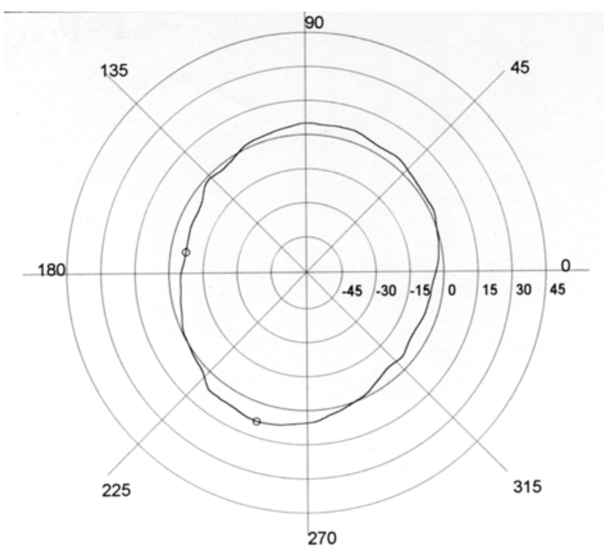


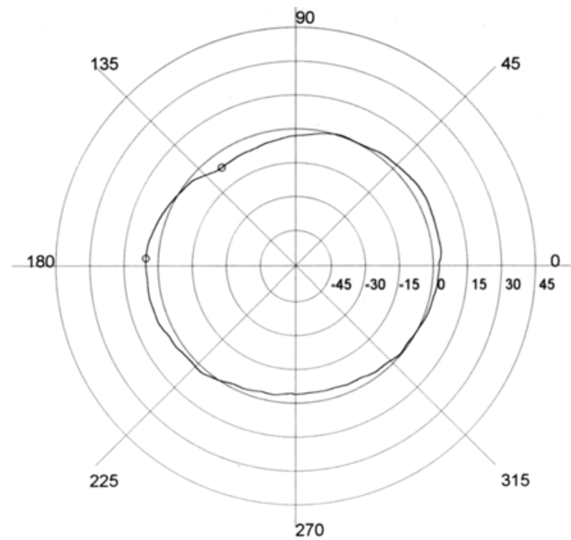


Al_2O_3

Hyperbole side

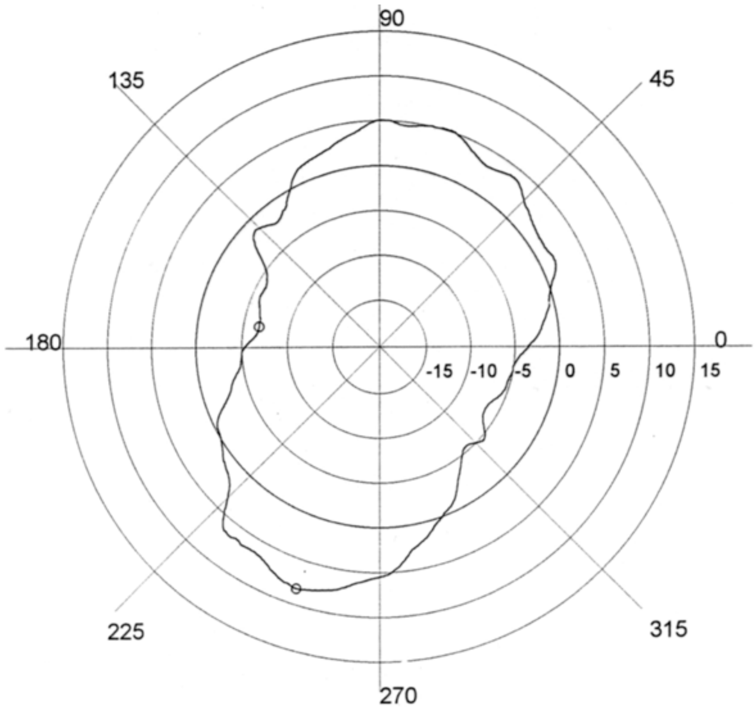
Parabola side



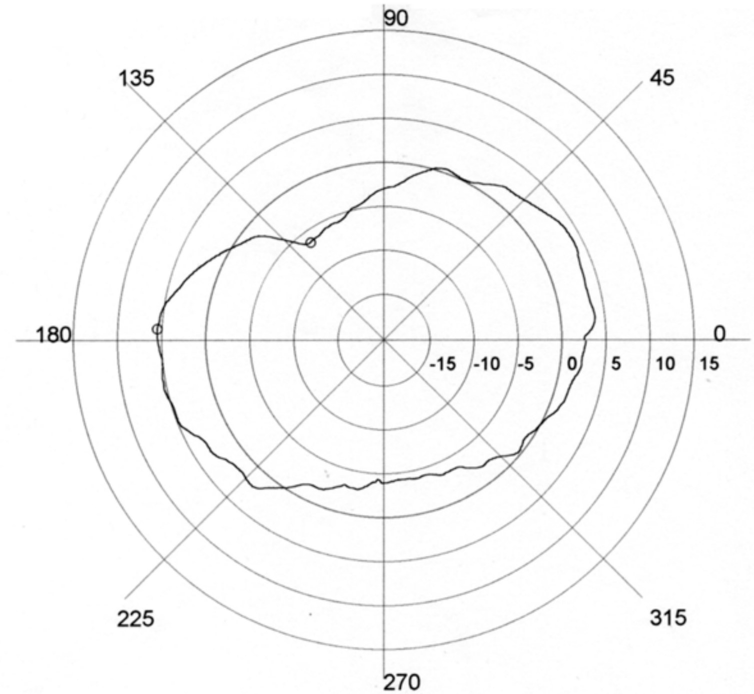


SiC

Thin wall (1 *mm*) SiC shell circularities *



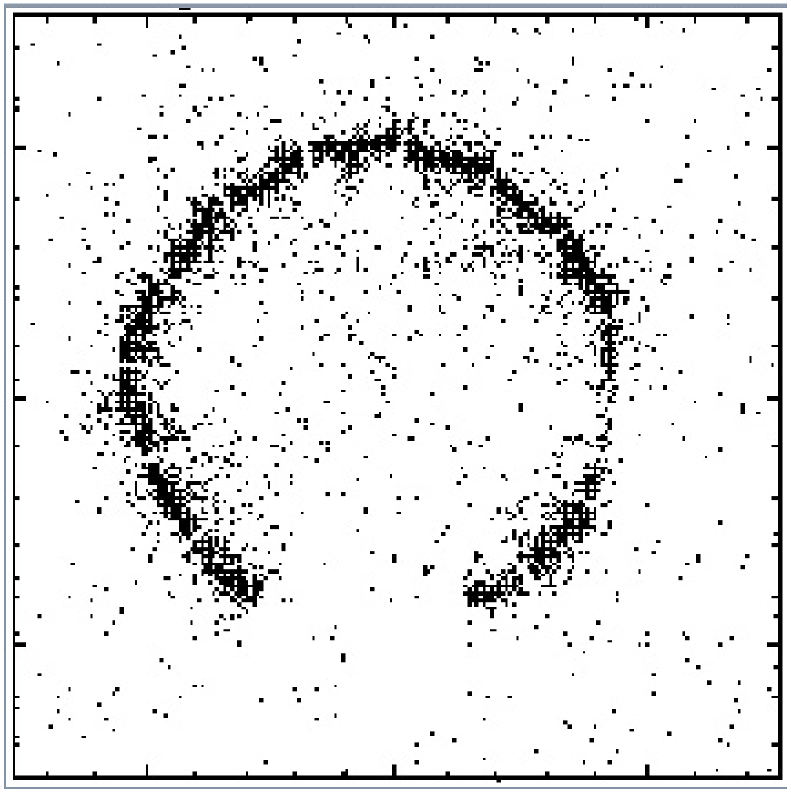
Hyperbole side



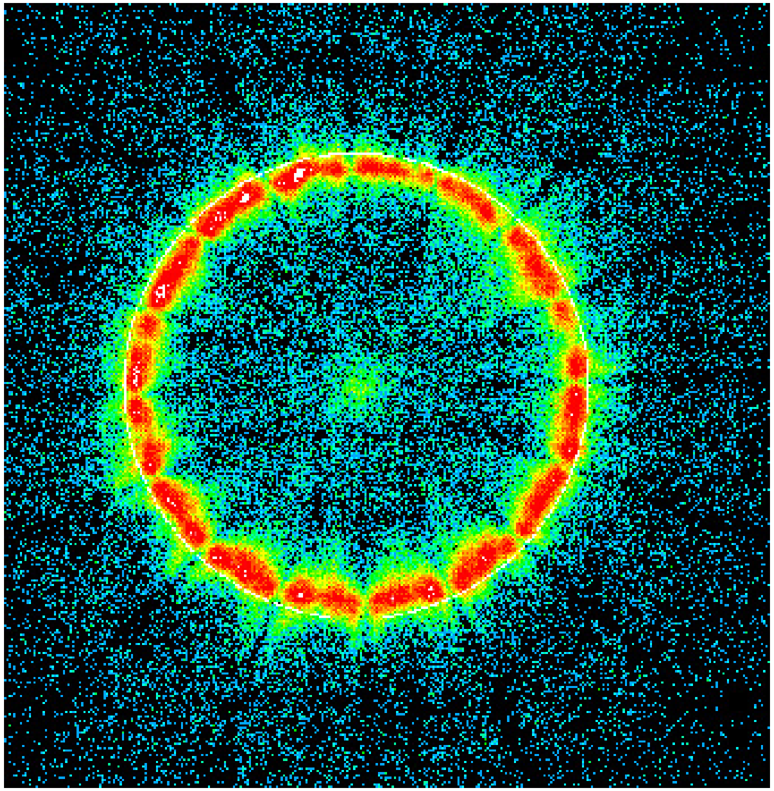
Parabola side

* Scale in microns

Intrafocus rings at 1.5 KeV

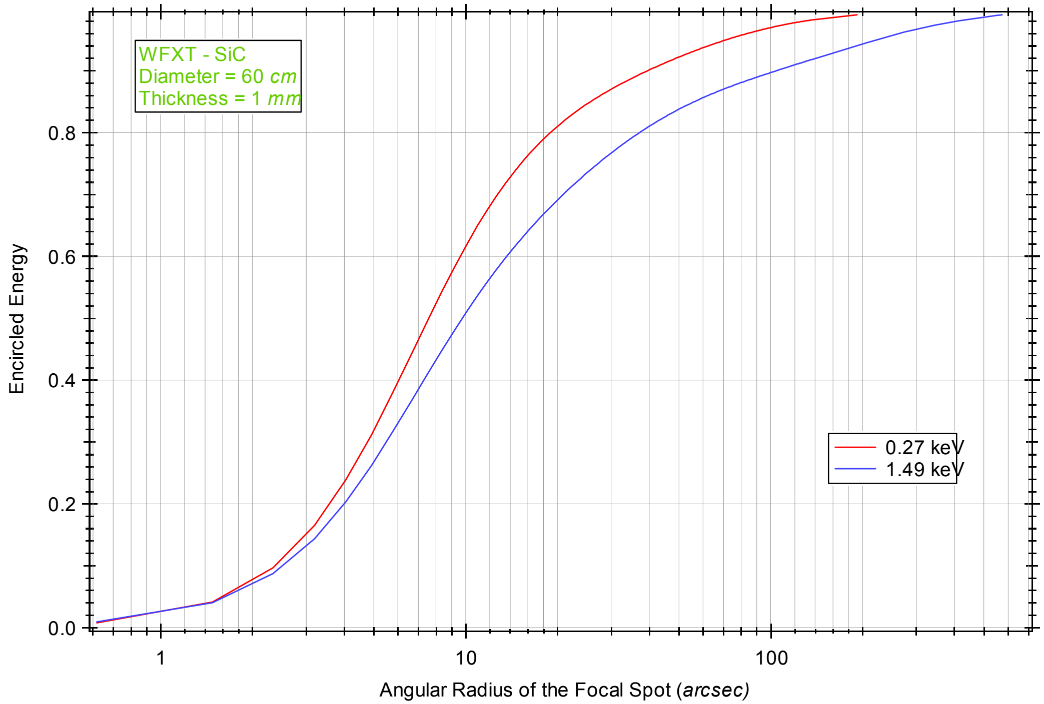


SiC-2 Shell (2 mm thick)
Marshall XRCF (1999)



SiC-4 Shell (1 mm thick)
Panter MPE (2001)

Encircled Energy Function and *HEW* derived by the X-Ray imaging tests performed at the *Panter-MPE* facility (March 2001)



Energy (*keV*)	1 *mm* shell - Panter 2001 HEW (*arcsec*)	2 *mm* shell - Marshall 1999 HEW (*arcsec*)
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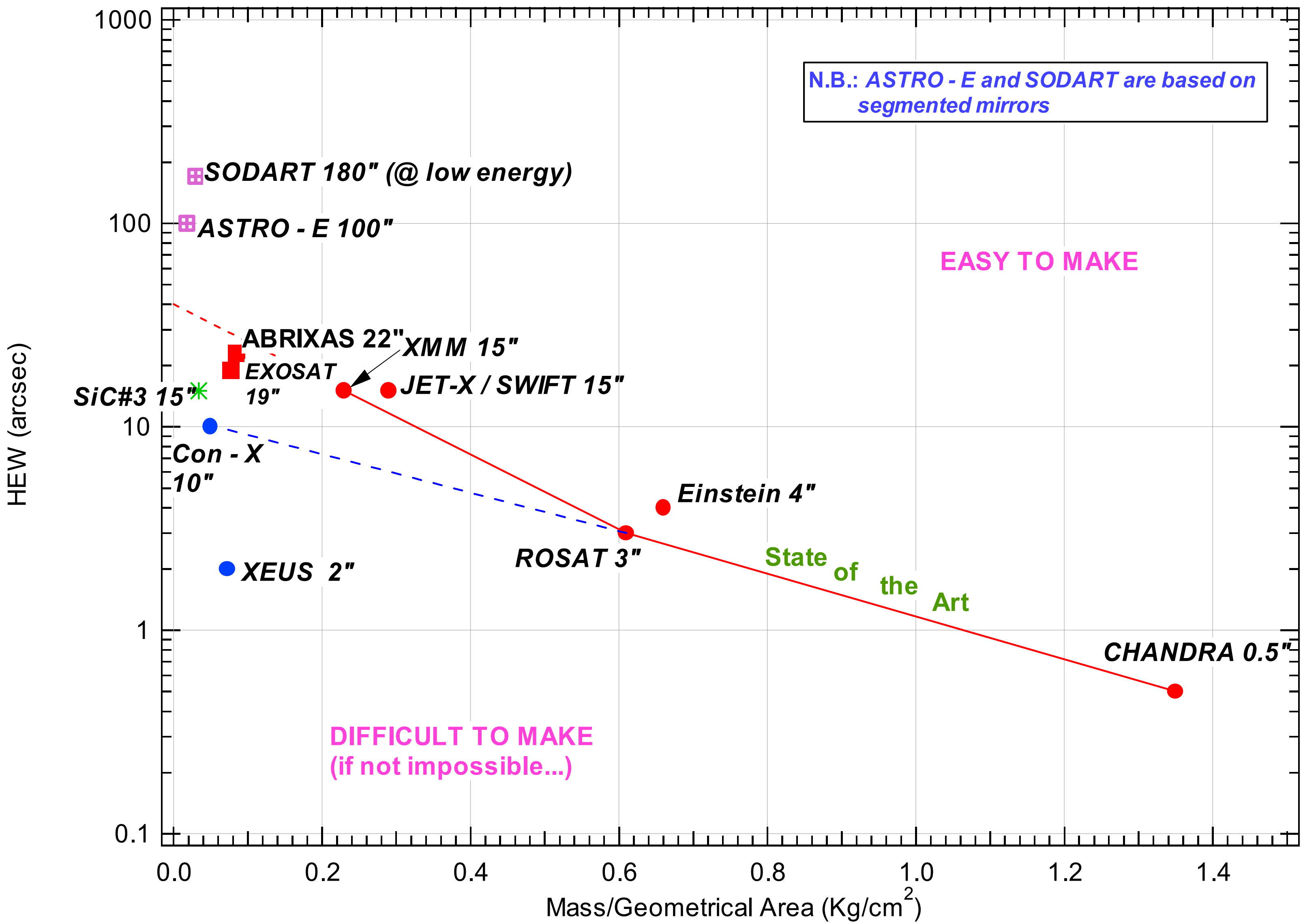
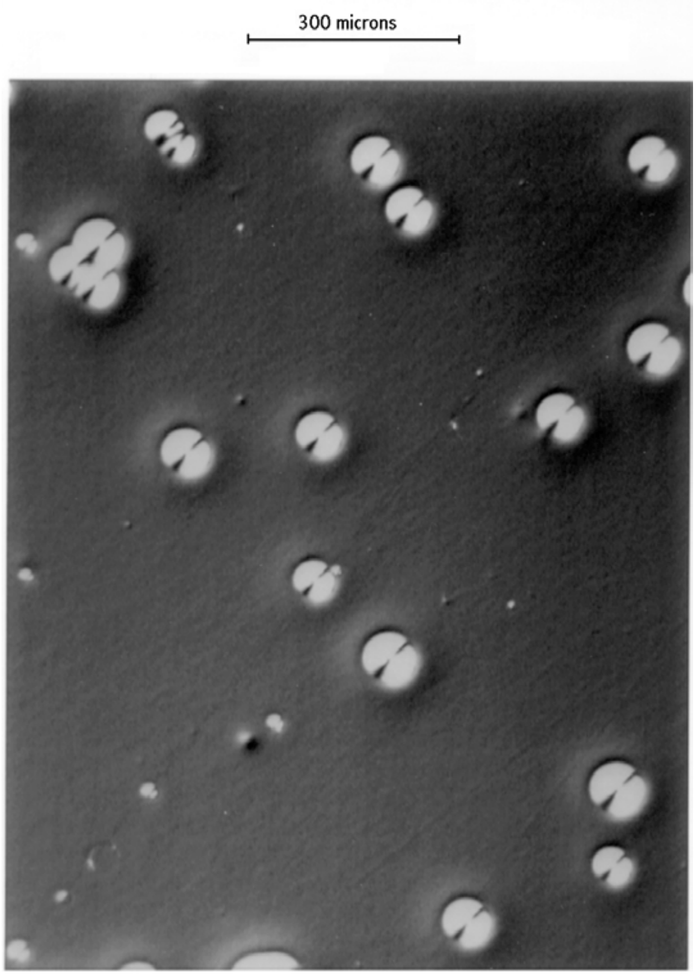
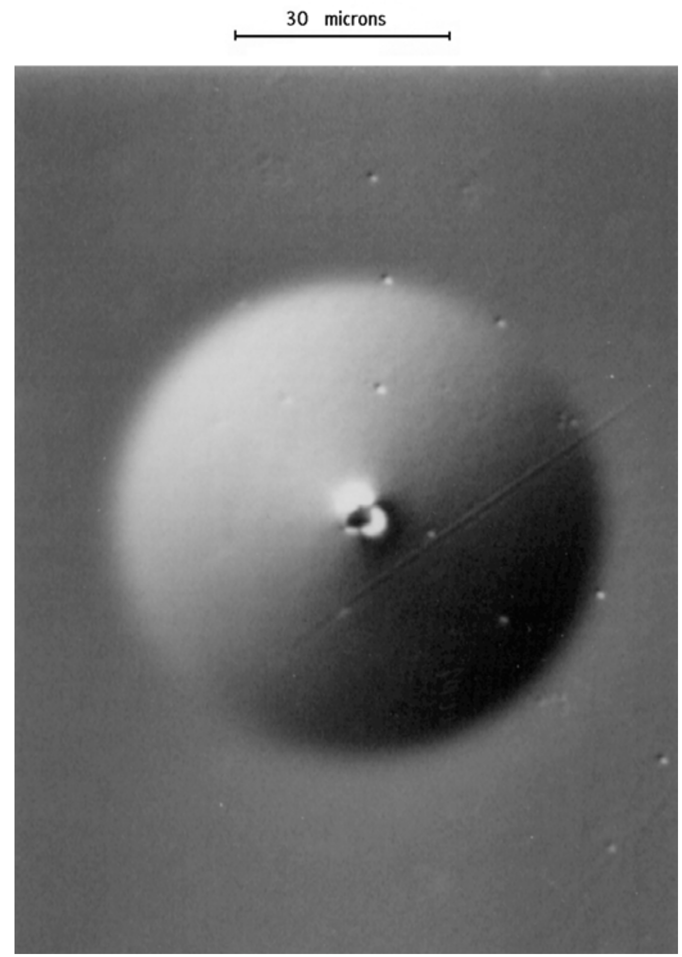
0.108	-----	*10.5 (aver.)*
0.277	*15.12*	*13.5 (aver.)*
1.49	*19.97*	*24.9 (aver.)*



N.B.: ASTRO - E and SODART are based on segmented mirrors
SODART 180" (@ low energy)
ASTRO - E 100"
EASY TO MAKE
ABRIXAS 22"
XMM 15"
EXOSAT 19"
JET-X / SWIFT 15"
SiC#3 15"
Con - X 10"
Einstein 4"
ROSAT 3"
XEUS 2"
State of the Art
CHANDRA 0.5"
DIFFICULT TO MAKE
(if not impossible...)
HEW (arcsec)
1000
100
10
1
0.1
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
Mass/Geometrical Area (Kg/cm2)

Nomarsky microscope images showing the presence of microbubbles on the MS gold surface (perhaps probably due to water vapour contamination during the mirror shell epoxy replication)





Possible Improvements:

↓ elimination of the presence of microbubbles on the mirror Au surface avoiding the contamination by H_2O vapor during the epoxy replication
⇦ the process will be performed into a more "*clean*" environment;

↓ use of mandrels allowing us to make mirrors with a more favorable height-to-diameter aspect ratio (to minimize the *out-of-phase* circularity errors)

ΔR = *out-of-phase max. circularity deviation*

L = *mirror height* (L_{WFXT} = *24 cm* VS $L_{Con\text{-}X}$ = *60 cm*)

HEW contrib. = $\Delta R / L$ *rads*

⇦ ⇦ *With a Con-X mandrel the error contribution will be reduced by a factor* ***2.5*** *(assuming the same circularity deviation);*

↓ use of mandrels with a more favorable geometrical figure

intrinsic on-axis HEW error introduced by the mandrel

WFXT mandrel		*Zeiss - Con-X 50 cm mandrels :*
8 *arcsec*	**VS**	***5*** *arcsec*

Future Plans

- replication of a second SiC shell 1 *mm* thick exploiting the WFXT 60 *cm* diam. mandrel in order to verify:
    - ॐ the repeatability and possible improvements of the results already achieved;
    - ॐ the imaging performances after having removed the two stiffening rings.
- realization of a mirror shell exploiting one of the two 50 *cm* diam. mandrels manufactured by Zeiss for the Con-X / SXT feasibility study.

An investigation aimed to verify the possibility of using the reaction bonding technique to produce the SiC carries (a much cheaper approach compared to the CVD method utilized until now) is presently on course.